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ONR-AASERT grant #00014-94-1-1079 supported David W. Schloerb during the final three years of his doctoral studies in the Department of Mechanical Engineering at the Massachusetts Institute of Technology (MIT), from August 1, 1994 to May 31, 1997. Schloerb's research was supervised by Nathaniel I. Durlach as part of the Virtual-Environment Technology for Training (VETT) project at MIT (Parent Award entitled "Research on Human Responses to Alterations of Sensorimotor Loops Associated with the use of VE Systems," Contract N61339-93-C-0047). Schloerb completed his Ph.D. and graduated in June, 1997.

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Psychophysical Research on Telepresence
ONR-ASSERT Grant #00014-94-1-1079

September 11, 1997

Principal Investigator:

Mr. Nathaniel I. Durlach
Massachusetts Institute of Technology

Parent Award:

Research on Human Responses to Alterations of Sensorimotor Loops Associated with the use of VE Systems

Contract N61339-93-C-0047

Introduction

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The AASERT proposal states that Schloerb's initial goals were to "construct an operational definition of telepresence, determine the factors that lead to telepresence, and understand the relationship between telepresence and objective performance." Although his prior work on telepresence was promising, leading to a journal article (Schloerb, 1995), continuation of this line of research proved to be difficult under the AASERT grant. The initial problem was too general and Schloerb was compelled to re-focus his efforts after only a few months. The research ultimately focused on a small part of the original problem: adaptation of perceived depth related to changes of the effective interpupillary distance in computer-graphic stereoscopic displays. The experimental study, which made use of apparatus (the Virtual Workbench) that was developed as part of the VETT project, is documented in Schloerb's Ph.D. thesis (1997).

Preliminary Work on Telepresence

Subjective telepresence may be defined quantitatively in terms of the probability that the human operator (of a teleoperation system) will perceive him or herself to be located in the remote environment (where the teleoperator is located). This idea, which may be extended to include virtual environments, is developed in Schloerb's paper (1995).

Given this theoretical approach one might vary parameters of a teleoperation system in an experiment and observe how the degree of subjective telepresence varies (and thus attempt to understand "the factors that lead to telepresence"). The "parameters" of a telepresence system (varied in the experiment) may be effectively summed-up by describing the way the system transforms the human operator's interaction with the remote environment and, ultimately, one could study telepresence in terms of sensorimotor transformations in general, without regard to a specific teleoperation system. One could also observe

how objective performance in a remote task is affected in such a test in an attempt to understand the relationship between subjective telepresence and task performance.

Unfortunately, the problem is complicated. Tasks and performance measures are arbitrary and, hence, there is no general relationship between subjective telepresence and task performance. One might hope to identify some class of tasks where a positive relationship exists (so that subjective telepresence might serve as a design goal in special cases), but this is best guided by further theoretical insight that has not been forthcoming.

Another complicating factor is that people adapt to sensorimotor transformations. Hence performance varies in time. This problem, a significant one in its own right, served as the focus of Schloerb's ultimate research.

Schloerb's Ph.D. Thesis

Schloerb investigated how people adapt to a single visual transformation while performing various tasks with a computer-graphic stereoscopic display. Specifically, experiments were performed with human subjects in order to observe how perceived depth changes over time when the effective interpupillary distance (IPD) is changed. An important objective of the research was to test the results against a preliminary model of adaptation developed by Shinn-Cunningham in connection with auditory localization (1994). Another goal was to find out whether task performance can be improved by increasing the effective IPD of the display relative to the human operator's actual IPD.

The experimental results show that depth resolution is improved, under certain conditions, when the effective IPD is increased, and that human operators adapt more or less completely to the transformation in an absolute identification task. In other words, the bias in the operators' response, initially caused by the transformation, gradually disappears. The fact that computer-graphic displays are divided into discrete pixels was found to have subtle consequences, however, that may limit performance in some cases. The observed shifts in bias and resolution are roughly consistent with the preliminary adaptation model, although limitations of the model were also identified.

Product Note

At the time of this report, the only existing publication that was directly supported by the AASERT grant is Schloerb's thesis (1997). It is anticipated that a number of papers based on this work will be published in the future.

References

Schloerb, David W. 1995. A Quantitative Measure of Telepresence. *Presence: Teleoperators and Virtual Environments* 4 (1):64-80.

Schloerb, David W. 1997. Adaptation of Perceived Depth Related to Changes of the Effective Interpupillary Distance in Computer-Graphic Stereoscopic Displays. Ph.D., M.I.T.

Shinn-Cunningham, B.G. 1994. Adaptation to Supernormal Auditory Localization Cues in an Auditory Virtual Environment. Ph.D., M.I.T.

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